HydroShunter

Emergency Services Briefing Note

1001-04-0019

1. Introduction

The HydroShunter locomotive is the UK's first hydrogen-powered locomotive, and is primarily based at the Severn Valley Railway, in Kidderminster, Worcestershire. It is based on a British Rail Class 08 locomotive, built as a diesel-powered locomotive. The HydroShunter locomotive uses a large lead-acid traction battery, alongside a hydrogen fuel cell in a hybrid configuration to provide electrical power to the locomotive's traction motors. A maximum of 20 kg of hydrogen fuel is stored onboard as a high-pressure gas in four cylinders.

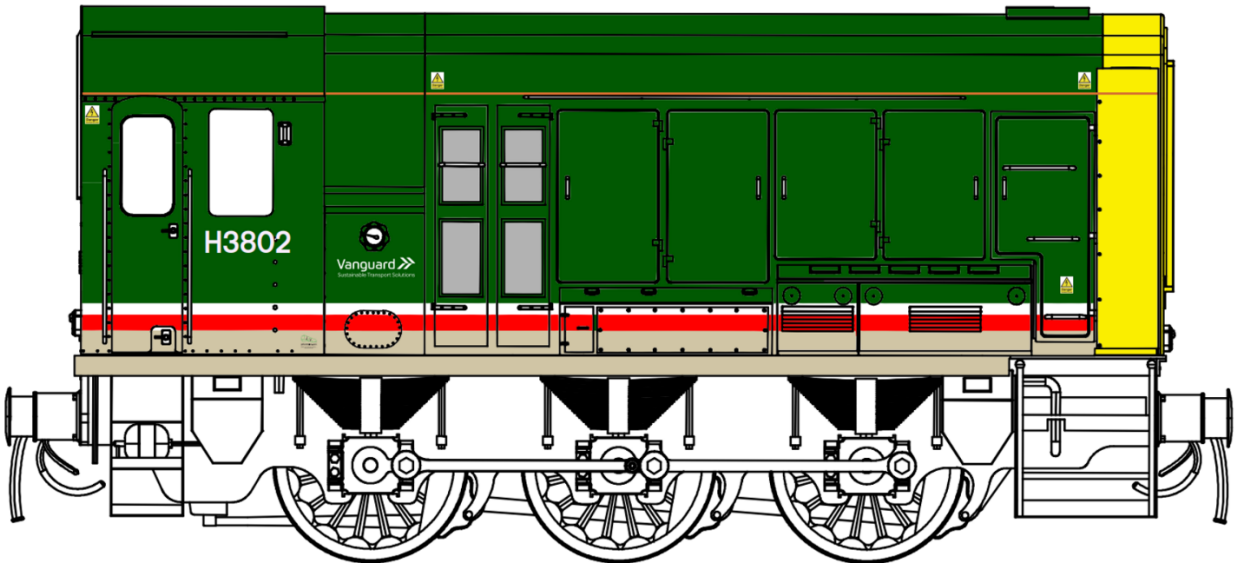
This briefing note is intended to provide emergency services with the key information about the locomotive in the event of an incident. The types of incidents that may require emergency services support are:

- Warning alarm sounding (possible hydrogen leak, high heat detection or fire)
- Fire on board (or near the locomotive)
- Significant collision or derailment.

2. Design of HydroShunter

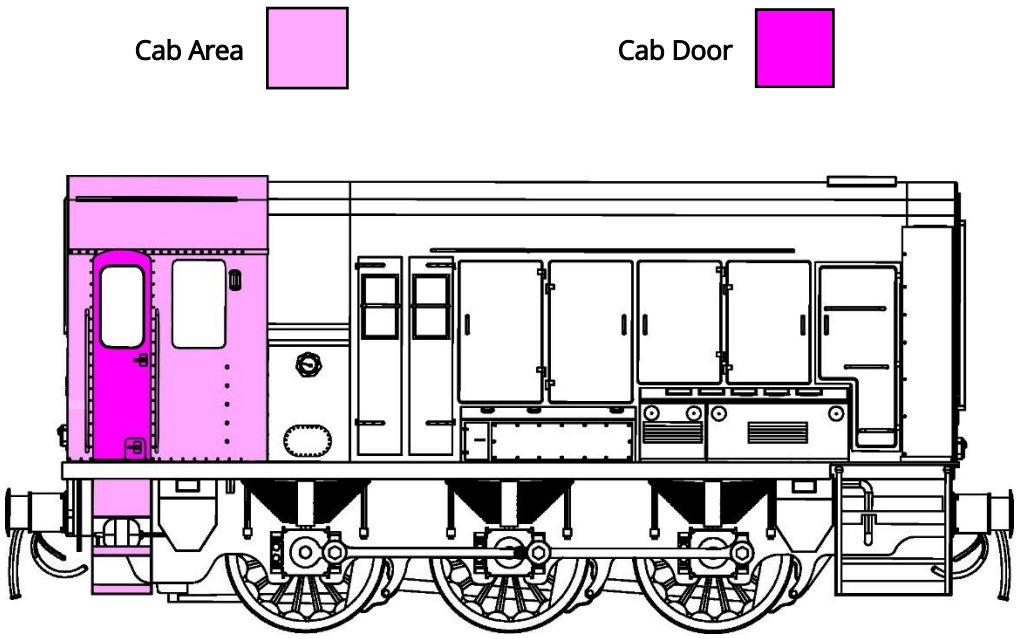
HydroShunter is a locomotive, intended to move other railway vehicles for short distances, at slow speeds, typically within the confines of a single railway yard, station or depot.

To date, only one HydroShunter has been developed. It can be identified from other diesel-powered Class 08 locomotives by the distinctive green livery, 'Vanguard' branding, and number **H3802** displayed on the cab sides.



The only personnel onboard the locomotive are drivers and other traincrew. They will be located in the locomotive's cab, accessed by two cab doors (one each side). It is possible that the Severn Valley Railway will use the locomotive to haul passenger coaches to showcase the technology, but this will not be done routinely.

Each door is accessed by cab steps from ground level. The location of the locomotive's cab and cab door is shown below.



A portable hydrogen leak detector, or 'hydrogen sniffer' is kept in the locomotive's cab and used by the driver during locomotive start-up procedures to check the fuel system for leaks.

This hydrogen leak detector can be used by the emergency services to check for the presence of hydrogen gas following an incident. The instruction manual for the hydrogen leak detectors can be found in Appendix A to this document.

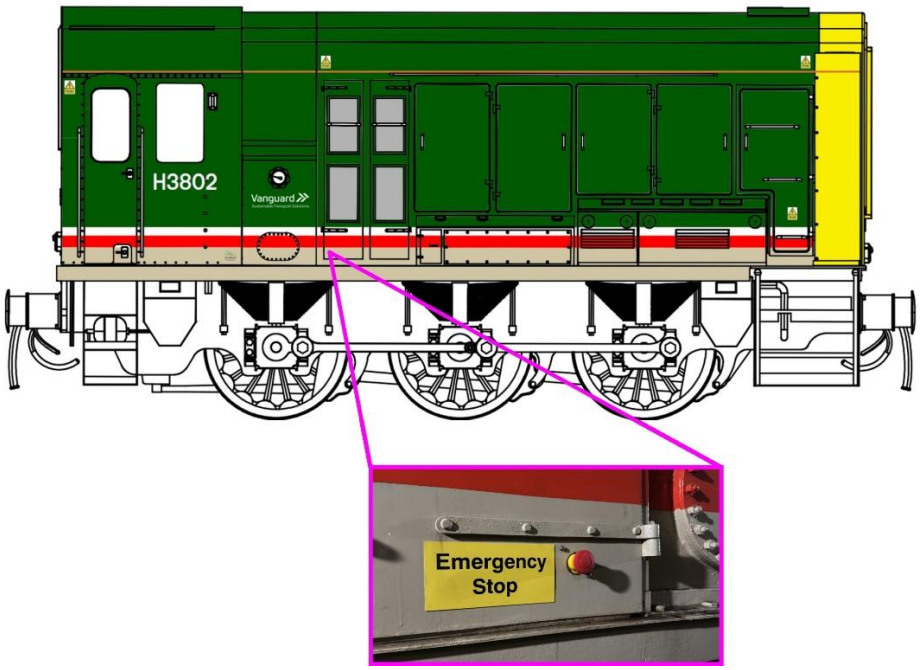
2.1. High-Voltage Equipment

High-voltage electrical equipment is used throughout the locomotive, as part of the propulsion system.

Assume that high-voltage electrical equipment onboard the locomotive is live, until

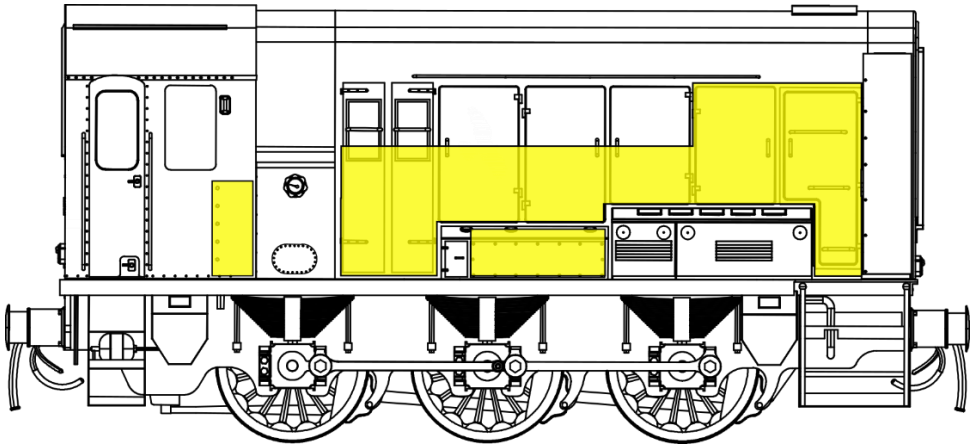
- The traction battery has been isolated
- The hydrogen fuel cell has been isolated or has shut down

The hydrogen fuel cell can be automatically shut down by pressing either of the 'Emergency Stop' buttons, present on both sides of the locomotive. These are identified in the image below.



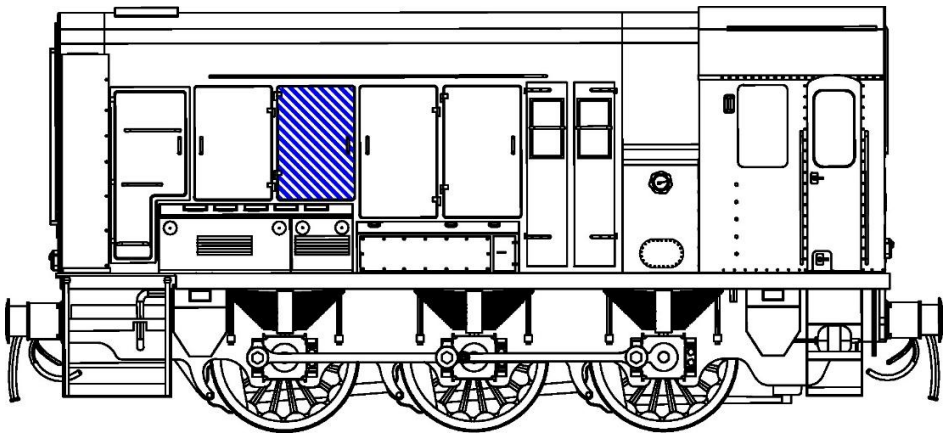
Before these high-voltage systems have been isolated or have shut down, high-voltage equipment may remain live behind bodywork/panels shown below.

Areas containing high-voltage equipment



The main (traction) battery isolation switch can be found behind the third door panel on the left-hand-side of the locomotive, as show below.

Traction Battery Isolation Switch Location



When this switch is on the vertical position, the battery is connected. When the switch is in the horizonal position, the battery is isolated. When isolated, there will be no electrical power to/from the traction batteries, but cables and connections may still be live and so it is recommended that Emergency Services Standard Operating Procedures for rail vehicles is followed.

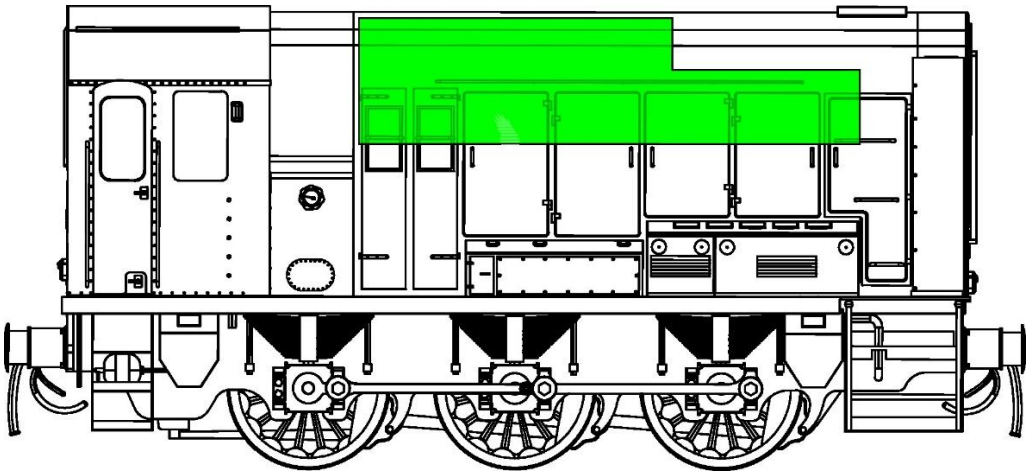
2.2. Compressed Hydrogen Systems

The locomotive stores hydrogen as a compressed gas, at a maximum pressure of 350 bar. The hydrogen is stored in 4 separate high-pressure cylinders. Gaseous hydrogen forms an explosive atmosphere in concentrations of 18% to 59% in air and is flammable in concentrations of 4% to 75% in air. Hydrogen burns with in invisible flame. Compressed hydrogen has UN and HAZCHEM identifying codes shown below.

The locomotive utilises much of the technology developed for hydrogen-powered road vehicles. Many of the same emergency procedures developed for hydrogen-powered road vehicles (e.g. hydrogen-powered bus & truck fleets) can be directly applied to the HydroShunter locomotive.

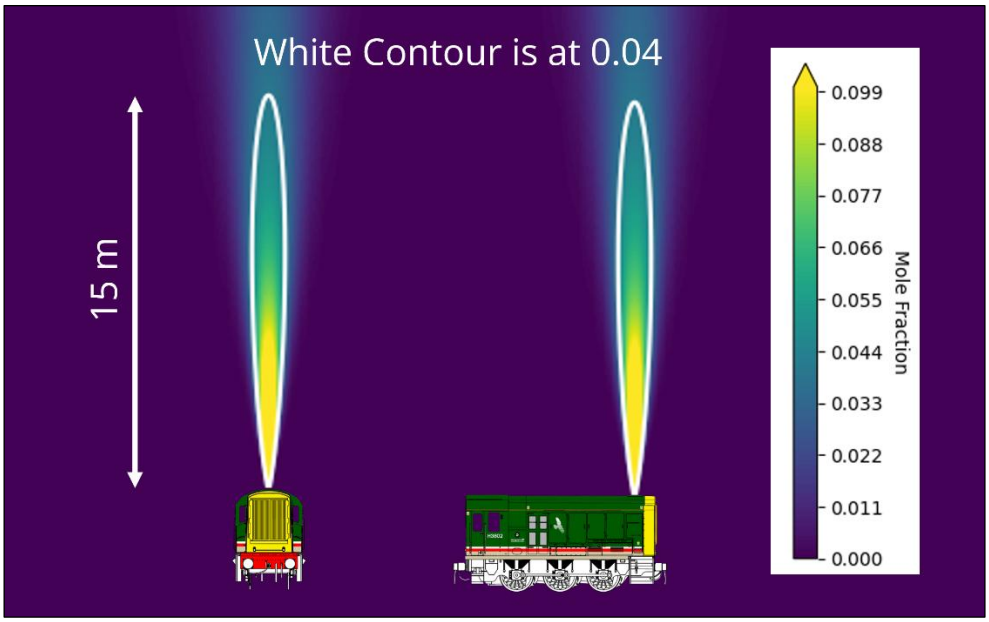
The four cylinders used onboard the locomotive are type III pressure vessels, with an aluminium liner and a carbon fibre wrap. All elements of the compressed hydrogen system (storage cylinders, fuel systems, pipework and hydrogen fuel cell) are located in the areas identified below.

Compressed hydrogen systems

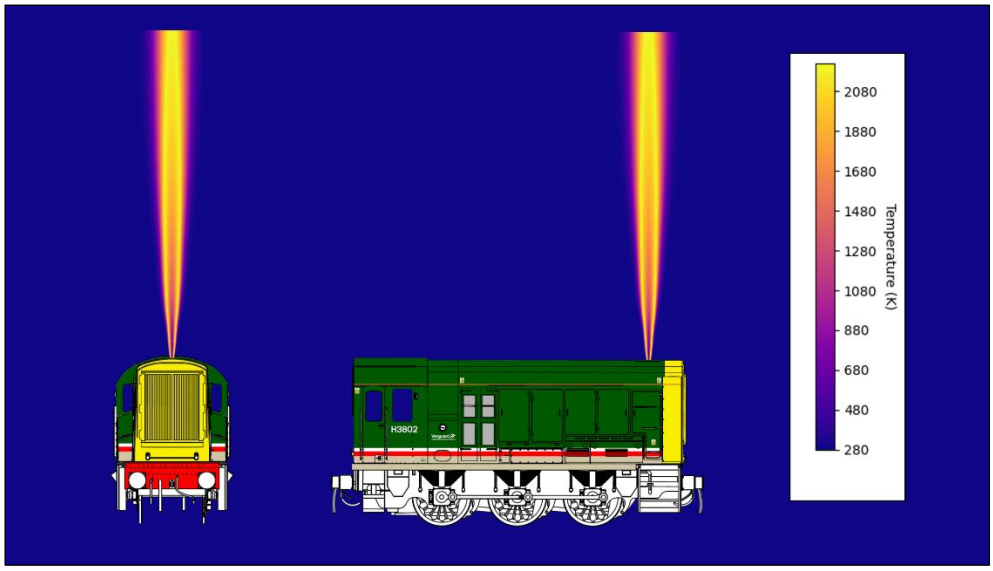


Each hydrogen storage cylinder is fitted with two Thermally-activated Pressure Relief Devices (TPRDs), which are passive components that act to automatically vent the stored hydrogen to atmosphere in the event of a vehicle fire, to protect against an excessive pressure in the cylinders, leading to a cylinder rupture. Each TPRD (two fitted to each cylinder for redundancy) 'activates' at 110°C ± 5°C, automatically venting hydrogen fuel upwards, out of the roof of the vehicle.

Should these TPRDs 'activate', venting hydrogen to atmosphere, a flammable cloud of vented hydrogen will form for the time taken for the cylinders to completely vent (approx. 2 minutes). The location and relative size of this flammable cloud is shown below.



Should this vented flammable cloud be ignited, a jet flame will form. This jet flame will be sustained by the fuel being vented from the locomotive's hydrogen storage system, until the fuel is depleted. Should this occur, the entire inventory of hydrogen fuel will be depleted in no longer than 2 minutes. Automatic venting (both ignited and unignited) will be associated with a loud roaring sound for the duration of the venting. The location and relative size of this jet flame is shown below.



It should be noted that the colours in the figure above only act to indicate the flame temperature, as hydrogen burns invisibly, the jet flame will appear almost entirely invisible.

While the flame has a relatively high temperature, hydrogen flames have a low radiated heat. Therefore, the temperature of the flame is unlikely to be felt from platform or ground level. Therefore, the use of a thermal imaging camera is recommended before approaching HydroShunter.

2.3. Alarms & Alerts

Several hydrogen leak detector sensors are located above the fuel cell and fuel tank areas. If a leak is detected, the fuel supply is automatically shut off, sealing the hydrogen in the tanks. The driver will also be notified of a hydrogen leak through an audible alarm and warning light in the cab.

Heat detection sensors are fitted above the traction battery, fuel cell and hydrogen cylinders. Should these detect excessive temperatures, the fuel supply is automatically shut off, sealing the hydrogen in the tanks, sound an alarm to the driver and illuminate a warning light.

3. Emergency Response by Operator

In the event of an emergency with a driver onboard, the driver and onboard traincrew will take control of the immediate safety of any onboard passengers.

If a fire or hydrogen leak is detected, the train driver will follow pre-agreed operating practices which will include:

- Stop the train in a safe position, avoiding tunnels, viaducts and covered stations if possible
- Contact the signaller to state the nature of the emergency and request that all other trains in the local area are stopped
- Request the support of the emergency services (if required)
- Press the e-stop button when the train has stopped in a safe position. This will shut off the hydrogen supply and immediately power down the fuel cell and traction battery
- If operating a passenger train, carry out emergency evacuation of passengers to a safe position to 100 metres in accordance with safe industry practice (depending on the nature of the emergency)
- Take the portable hydrogen detector located in the cab to the evacuation point
- Brief the emergency services and handover the hydrogen detector

In the event that the driver is incapacitated, the onboard train crew will take control of the emergency and contact the signaller.

4. Useful Contact Numbers

Name	Role	Number
Ben Aitken	HydroShunter Project Manager, Vanguard	(+44) 7572 289754
Callum Nicolson	HydroShunter Project Engineer, Vanguard	(+44) 7546 795240
Martin White	Head of Traction & Rolling Stock, Severn Valley Railway	(+44) 7400 460659

Appendix A – Testo 316-EX Hydrogen Leak Detector Instruction Manual

testo 316-EX · gas leak detector

Instruction manual

1 Safety and the environment

1.1. About this document

Use

> Please read this documentation through carefully and familiarize yourself with the product before putting it to use. Pay particular attention to the safety instructions and warning advice in order to prevent injuries and damage to the products.

> Keep this document to hand so that you can refer to it when necessary.

> Hand this documentation on to any subsequent users of the product.

1.2. Ensure safety

> Do not operate the instrument if there are signs of damage at the housing, mains unit or feed lines.

> Only operate the product properly, for its intended purpose and within the parameters specified in the technical data. Do not use any force.

> Do not store the product together with solvents. Do not use any desiccants.

> Only use the device in closed, dry rooms and protect it from rain and moisture.

> Carry out only the maintenance and repair work on this instrument that is described in the documentation. Follow the prescribed steps exactly. Use only original spare parts from Testo.

1.3. Protecting the environment

> Dispose of faulty rechargeable batteries/spent batteries in accordance with the valid legal specifications.

> At the end of its useful life, send the product to the separate collection for electric and electronic devices (observe local regulations) or return the product to Testo for disposal.

2 Specifications

2.1. Use

The testo 316-EX is a gas leak detector for the short-term detection of gases in areas at risk of explosion according to Directive 2014/34/EU (ATEX).

Areas of application are the gas detection in rooms and the location of leaks at gas systems. The instrument is designed for use by trained personnel.

For operation in areas at risk of explosion, also observe the **Safety instructions** document.

Explosion limits of flammable substances

A flammable substance in the air has a lower explosion limit (LEL) and an upper explosion limit (UEL). The air/gas mixture is flammable anywhere between these two limits, potentially leading to an explosion (critical range). Below the LEL, the mixture is too lean for an explosion, and above the UEL it is too rich (non-critical range).

The explosion limits depend on the substance:

- Methane CH4: LEL 4.4 vol% / UEL 16.5 vol%
- Propane C3H8: LEL 1.7 vol% / UEL 10.9 vol%
- Hydrogen H2: LEL 4.0 vol% / UEL 77.0 vol%

Restrictions of the application range

Do not use the instrument as a monitoring instrument for personal safety! The testo 316-EX is no protective equipment!

Do not use the instrument as a gas analyzer! The sensor detects almost all flammable gases to the same extent.

2.2. Technical data

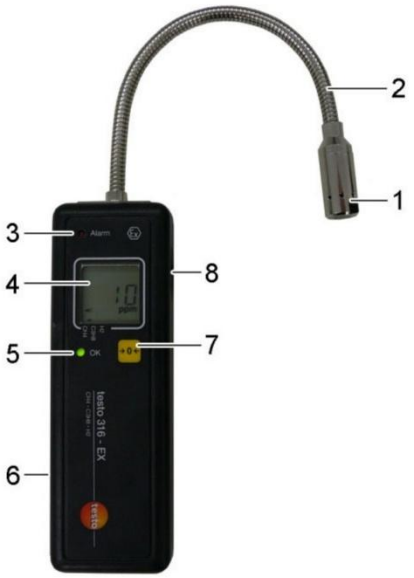
Characteristic	Values
Type	Semi-conductor
Response threshold	1 ppm
Reaction time (t90)	14 s
Measuring range	Methane CH4: 0 ppm up to 2.5 vol% Propane C3H8: 0 ppm up to 1.0 vol% Hydrogen H2: 0 ppm up to 2.0 vol%
Accuracy (at 20 to 50 % RH, 0 to 40 °C/32 to 104 °F)	at 100 ppm: -50 ppm to +150 ppm at 0.1 vol%: -250 ppm to +0.2 vol%
Accuracy (at 20…50 % RH, -10 to 0 °C/ 14 to 32 °F)	at 100 ppm: -60 ppm to +150 ppm at 1,0 Vol%: -0,4 Vol% to +0,3 Vol%
Accuracy at 50% LEL (at 20 to 50 % RH, 0 to 40 °C/ 32 to 104 °F)	CH4 (2.2 Vol%): -0.2 to +0.2 Vol% C3H8 (1.0 Vol%): -0.2 to +0.3 Vol% H2 (2.0 Vol%): -0.2 to +0.2 Vol%
Resolution	at 0 to 999 ppm: 1 ppm at 0.1 to 2.5 vol%: 0.1 vol%
Power supply	2 x 1.5 V mignon/AA Type approved for use in areas at risk of explosion: Camelion Alkaline PLUS AA
Battery life	approx. 6 h (typical)
Storage/transport conditions	-10 to 50 °C / 14 to 122 °F 0 to 70 % RH
Operating conditions	-10 to 40 °C / 14 to 104 °F 20 to 80 % RH not condensing
Weight	approx. 200 g/0.44 lb. (incl. battery)
Dimensions (L x W x H)	Housing: approx. 135 x 45 x 25 mm / 5.31 x 1.77 x 0.99" Long, flexible sensor shaft including sensor head: approx. 200 mm/7.87"
Protection class	IP54

2 Specifications

Characteristic	Values
EC Directives	2014/34/EU (ATEX) EN 60079-0: 2012 + A11:2013 EN 60079-11: 2012
ATEX instrument labelling	CE 1258 Ex II 2 G Ex ib IIC T1Gb

3 Product description

3.1. Overview



1 Sensor head with gas sensor and exchangeable protection cap
2 Flexible sensor shaft
3 Alarm LED
4 Display
5 Readiness LED
6 Battery compartment (on rear)
7 Control key
8 On/off switch

4 First steps

4.1. Commissioning

Inserting batteries

✓ The instrument is switched off.

1. Open battery compartment (on rear of instrument) using enclosed Allen key.

Battery type approved for use in areas at risk of explosion: Camelion Alkaline PLUS AA

2. Insert batteries/rechargeable batteries (observe the polarity!).
3. Close battery compartment, tighten Allen head bolt by hand.

4.2. Getting to know the product

Switching on

Only switch on the instrument in fresh air as an automatic zeroing is performed at the end of the warm-up time. The ambient temperature during zeroing should correspond to the temperature at the measuring location. If required, zero again manually at the measuring location.

When not in use for a long period of time, the sensor becomes contaminated due to oxidation, causing the zero point to become unstable. If the instrument has not been in operation for a long period of time (> 2 weeks), it must be switched on approx. 30-45 minutes before use and thereafter zeroed manually.

If the instrument has been stored at temperatures <0 °C/<32 °F, it must be switched on 10 minutes before use and thereafter zeroed manually.

> Push up on/off switch on the right side of the instrument.

- The sensor is warmed up (duration: approx. 60 s).
  During the warm-up time, the following information is shown in succession:
  - All segments light up. Display segment test
  - **WAIT**: wait
  - **V3.03** (example): firmware version (important information in the event of service)

- **T126** (example): sensor table version (important information in the event of service)
- **PPM**: measuring unit, alarm LED (red) and status LED (green) alternately light up
- Display light is switched on
- **152** (example): check value (important information in the event of service)
- **CH4** (methane), **C3H8** (propane) or **H2** (hydrogen): set gas type
- **EN** (English), **DE** (German), **FR** (French), **ES** (Spanish), **IT** (Italian) or **CS** (Czech): set instrument language
- **batt** and bar graph: remaining battery capacity
- **NP** and two short signal tones: automatic zeroing is performed

- The instrument is ready for use if the status LED (green) lights up and a reading is shown in the display.
- With **ToN3** (readiness tone) function activated, a short signal tone is also emitted every 20 s as an indication of the readiness for operation.

Switching off

> Push down on/off switch on the right side of the instrument.

Set language

The instrument language is set to **EN** (English) in the condition on delivery. Proceed as follows to change the instrument language:

✓ The instrument is in the measurement view.

1. Press and hold **[--> 0 <--]** for approx. 8 s until a pulsed signal tone sequence sounds.
2. Repeatedly press **[--> 0 <--]** briefly until **LANGUA** is shown.
3. Press and hold **[--> 0 <--]** until the display changes.
4. Repeatedly press **[--> 0 <--]** briefly until the desired language is shown: **EN** (English), **DE** (German), **FR** (French), **ES** (Spanish), **IT** (Italian) or **CS** (Czech).
5. Press and hold **[--> 0 <--]** until the display changes.

- **EXIT** is displayed.

6. Press and hold **[--> 0 <--]** until the display changes.

- The instrument is once again in measurement view.

5 Using the product

5.1. Performing settings

Open configuration menu

✓ The instrument is in measurement view.

> Press and hold [--> 0 <--] for approx. 8 s until a pulsed signal tone sequence sounds.

- The instrument is in configuration view.

Selecting, opening and setting functions

> To select the next function: Briefly press [--> 0 <--].

> To open the selected function: Press and hold [--> 0 <--] until the display changes.

> To set the opened function: Briefly press [--> 0 <--].

> To end the function: Press and hold [--> 0 <--] until the display changes.

Adjustable functions

ℹ Ensure correct settings: All settings are applied immediately; there is no cancel function.

Function	Setting options/comments
LIGHT (display light)	OFF (display light cannot be activated) or ON (display light can be activated)
SOUND1 (alarm tone)	ON (acoustic alarm on) or OFF (acoustic alarm off). The frequency sequence of the alarm tone becomes faster with a higher concentration.
ALARM (alarm threshold)	Any value within the measuring range. ℹ If a value above the measuring range final value is set: The alarm tone sounds after reaching the measuring range final value (CH4: 2.5 vol%, C3H8: 1.0 vol%, H2: 2.0 vol%). The respective flashing number can be set; the number that can be set changes if a button is not pressed for 5 s.

Function	Setting options/comments
PROBE (detection characteristic curve)	**CH4** (methane), **C3H8** (propane) or **H2** (hydrogen)
SOUND3 (readiness tone)	**OFF** (readiness tone off) or **ON** (readiness tone on). A short signal tone every 20 s.
CONTRAST (display contrast)	Value between **0005** and **0025**
LANGUA (instrument language)	**EN** (English), **DE** (German), **FR** (French), **ES** (Spanish), **IT** (Italian) or **CS** (Czech)
Exit (close configuration menu)	-

5.2. Performing gas detection

CAUTION

Destruction of the sensor by external influences!

> Do not expose the sensor to high concentrations of H_2S (hydrogen sulphide), SO_x (sulphur dioxides), Cl_2 (chlorine) or HCl (hydrogen chloride).

> Avoid contact between alkaline materials or water and the sensor.

> Avoid the effect of moisture and frost on the sensor.

Have the instrument calibrated by the manufacturer annually.

Checking natural gas pipelines or hydrogen pipelines: Methane (the main constituent of natural gas) and hydrogen are lighter than air. The detection should take place above the line/the suspected leak.

Checking propane gas pipelines: Propane is heavier than air. The detection should take place below the line/the suspected leak, starting from the ground up.

> Guide the sensor head as near as possible and at a low speed (approx. < 2 cm per second) over the components that are to be checked for leaks.

- If the set alarm value is exceeded, the **Alarm** LED lights up red. If the acoustic alarm is switched on a warning tone also sounds,

the frequency sequence of which becomes faster as the concentration increases.

Manually perform zeroing

It is only possible to manually set the zero point if the gas concentration currently detected is below 1000 ppm.

Gas concentrations present at the point of the zeroing are suppressed by means of the zeroing. The reading shown therefore no longer conforms to the gas concentration actually present.

✓ The instrument is in the measurement view.

> Briefly press **[--> 0 <--]**.

- The zero point is reset.

Switching display light on/off

✓ The instrument is in the measurement view.

✓ The **LIGHT** function is activated.

> Press and hold **[--> 0 <--]** until a signal tone sounds.

- The display light is switched on or off.
- The display light automatically goes out if no buttons are pressed for 2 minutes.

6 Maintaining the product

Changing the batteries

Do not change the battery in areas at risk of explosion.

✓ The instrument is switched off.

1. Open battery compartment (on rear of instrument) using enclosed Allen key.

Battery type approved for use in areas at risk of explosion: Camelion Alkaline PLUS AA

2. Remove empty batteries and insert new batteries (observe the polarity!).
3. Close battery compartment, tighten Allen head bolt by hand.

Cleaning the instrument

> If the housing of the instrument is dirty, clean it with a damp cloth.

Do not use any aggressive cleaning agents or solvents! Weak household cleaning agents and soap suds may be used.

Clean protection cap

Contamination at or in the protection cap can be removed using compressed air.

CAUTION

Destruction of the sensor

> With the sensor protection cap open, take care that the sensor is not damaged.
> Do not direct the compressed air jet at the sensor, do not touch the sensor.

1. Carefully unscrew protection cap from sensor shaft.
2. Blow out protection cap and then screw on again.

7 Tips and assistance

7.1. Questions and answers

Question	Possible causes	Possible solution
Error is displayed.	Instrument error	> Contact Testo Customer Service or your dealer.
F30 is shown and the red LED lights up	Sensor faulty	> Contact Testo Customer Service or your dealer.
Zero point instable	Contamination of the sensor due to oxidation during long periods of non-use	> Leave instrument switched on until the zero point stabilizes (can take up to 45 minutes).
The instrument does not change to measuring mode (remains in the warm-up phase)	Battery voltage too low	> Change batteries.

If we could not answer your question, please contact your dealer or Testo Customer Service. You can find the contact data in the Internet under: www.testo.com/service-contact

7.2. Accessories and spare parts

Description	Article no.
Camelion Alkaline PLUS AA battery, 1 pc. Note: 2 batteries are required for the testo 316-EX	0515 0316
Sensor protection cap	0180 0316